Top Quark Mass Measurement by *Dynamical Likelihood Method* in the lepton+jets channel at CDF

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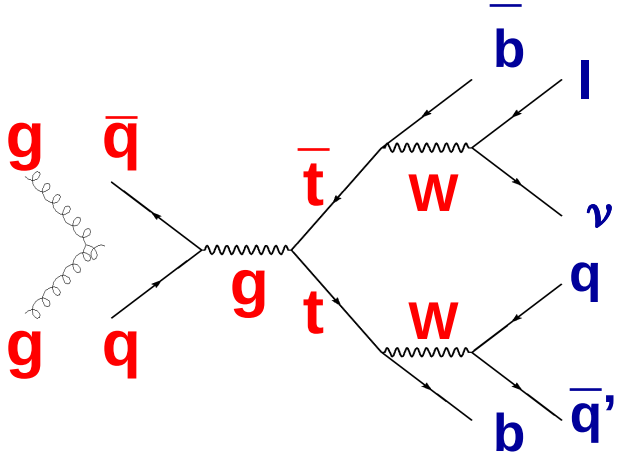
Introduction

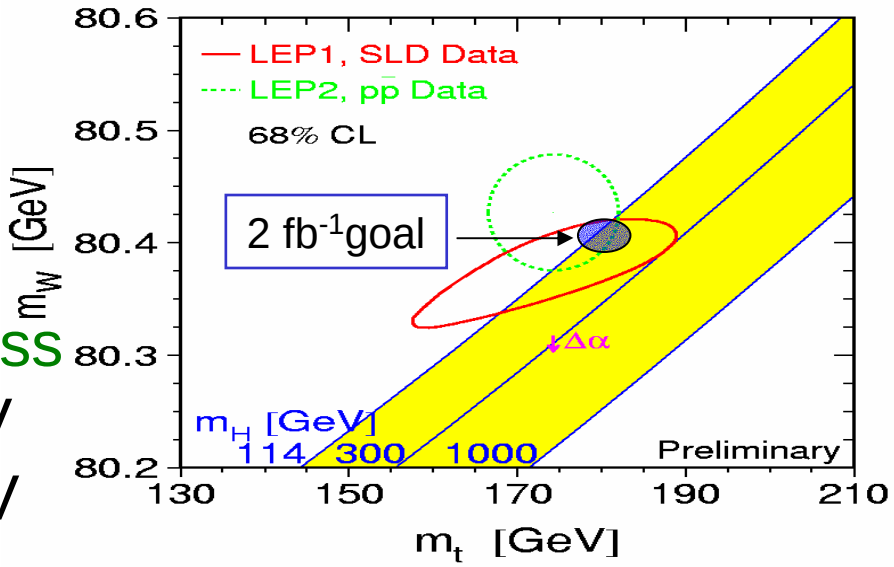
1) Decay Chain : $q\bar{q}$(85%), gg(15%) at sqrt(s) = 1.96 TeV



Kinematical cuts for "lepton+jets"

1) **One lepton : central electron / muon Et(Pt) > 20 GeV, |eta| < ~1.0**
2) **Met > 20 GeV**
3) **4 tight jets : Et > 15 GeV, |eta| < 2.0**
4) **At least 1 btag jets**

2) Precise measurement of M_{top} helps constrain of the mass of the Higgs. Goal : ~ 2 GeV!



3) RunI CDF & D0 combined Mass

Published : 174.3 ± 5.1 GeV

New(preliminary): 178.0 ± 4.3 GeV

What's DLM ?

- **The Method : CDF Original Method !**
  - Originally proposed in 1988 by K.Kondo.(J.Phys. Soc. 57, 4126)
  - The latest formulation was submitted to JPS recently.
    "A New Formulation of Dynamical Likelihood Method"
- **Formulation :**

For i-th event

M ; Prod,decay,propagator

$$L^i(M_{top}) = \int \sum_{combnsol} \sum \frac{2\pi^4}{Flux} |M|^2 F(z_1, z_2) f(p_t) w(\mathbf{x}, \mathbf{y}_t; \alpha) d\mathbf{x}$$

M **: Matrix element of tt process,** ***F*** **: Parton distribution function (Z_1,Z_2)**

f(p_t) **: Probability for the Pt of tt system.**

w **: Transfer function, x ; partons $\longleftrightarrow$ y ; observables**

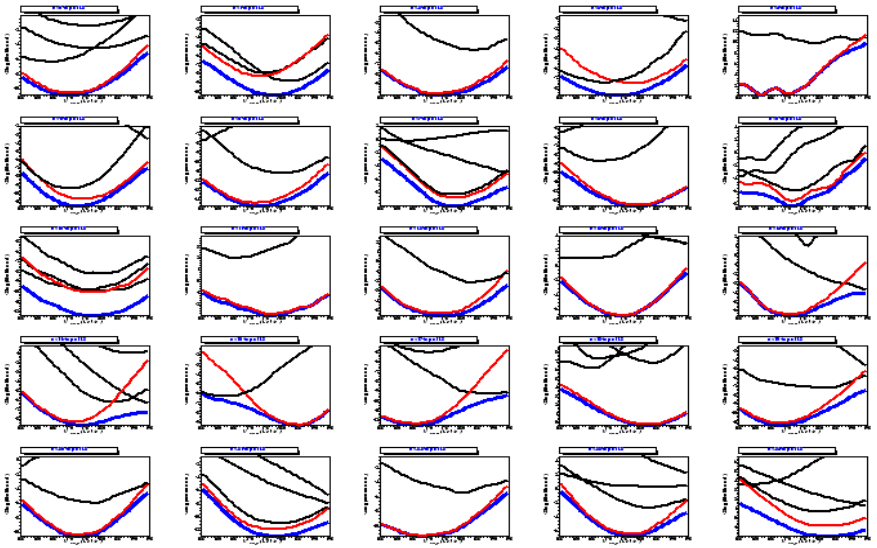
For all events

To obtain M_{top} , $\prod_{event} L^i(M_{top})$ $\longrightarrow$ ***Maximum likelihood Method***

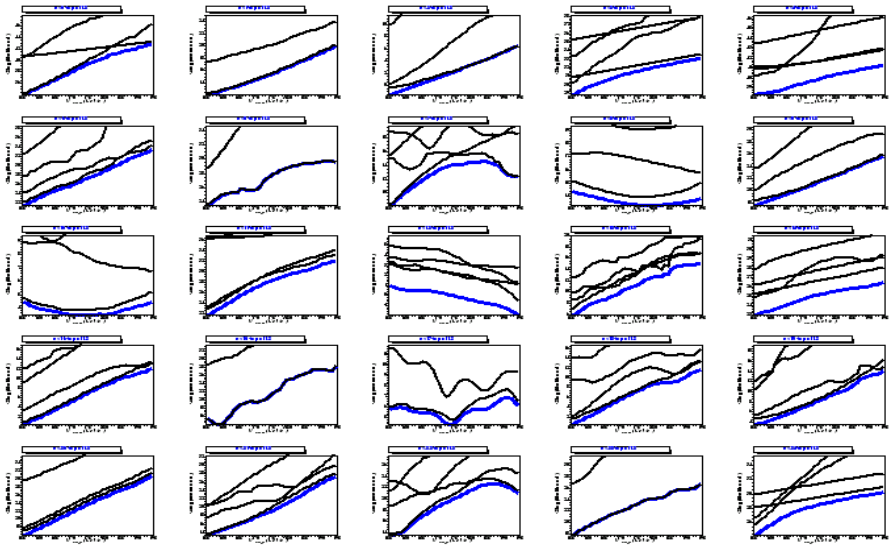
How Likelihood looks like?

25 events example for sig and bkg using generator level input

Signal example: - log(likelihood)



Bkg example: - log(likelihood)



Blue : all added up
Red : right comb.
Black : wrong comb.

Peak around 175 GeV

Range[155-195]GeV

Blue : all added up
Black : each comb.

Likelihood tends to be higher in lower mass region.

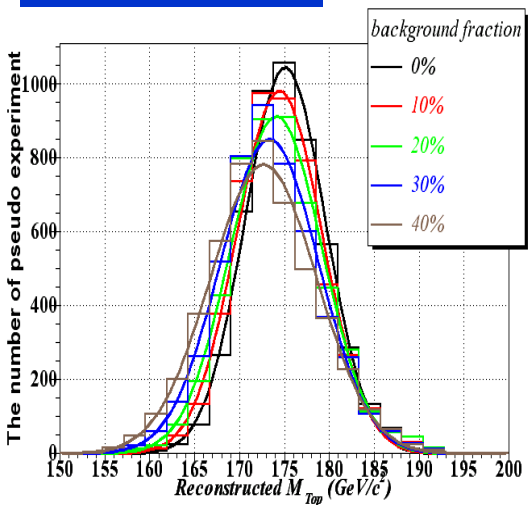
Backgrounds

- Expected background : 4.2 events (22 obsv.)
- Background pulls likelihood peak down.
- Pseudo experiments(22ev) by varying background fraction to look at effects on signal tt events.

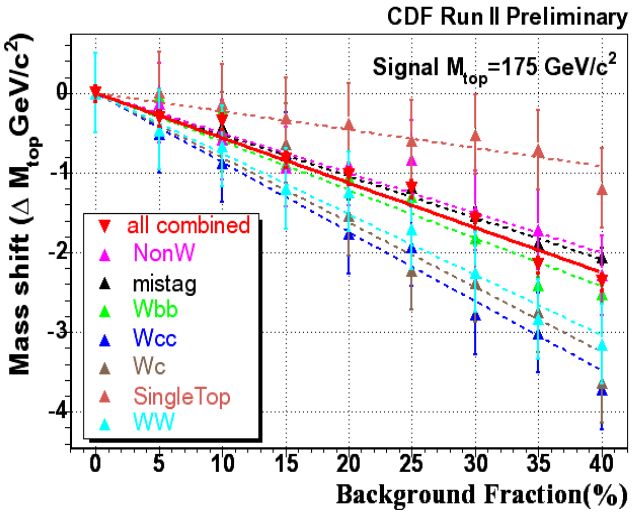
Background Summary

source	W+4j
Mistag	1.2 ± 0.37
Wbb	0.7 ± 0.29
Wcc	0.3 ± 0.12
Wc	0.2 ± 0.12
Single top	0.17 ± 0.03
WW	0.08 ± 0.05
nonW	1.6 ± 0.38
Bkg tot.	4.2 ± 0.71
N obs.	22
tt (6.7pb)	20.9

Mass shift



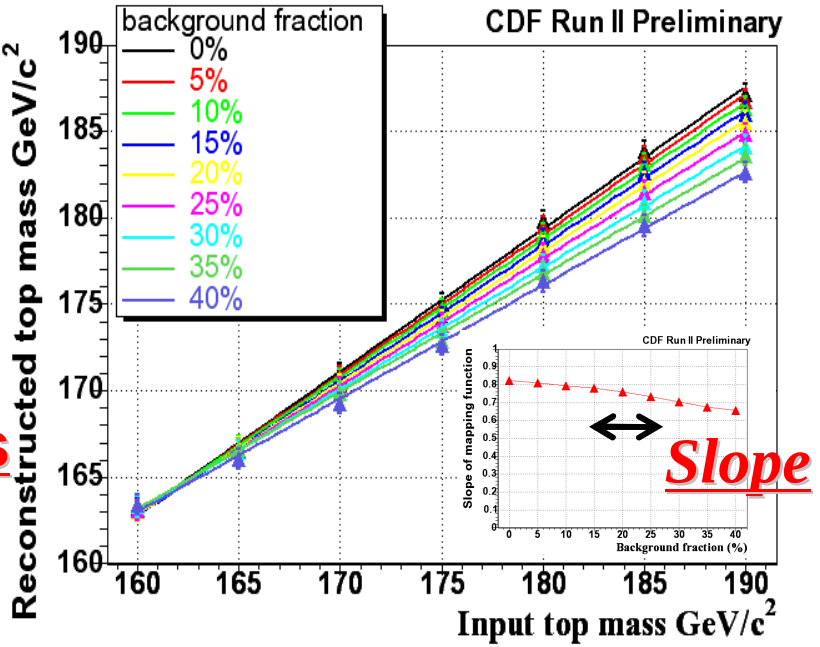
Each source effect



Need to evaluate how much shifted → **Mapping scheme !**

Mapping Function

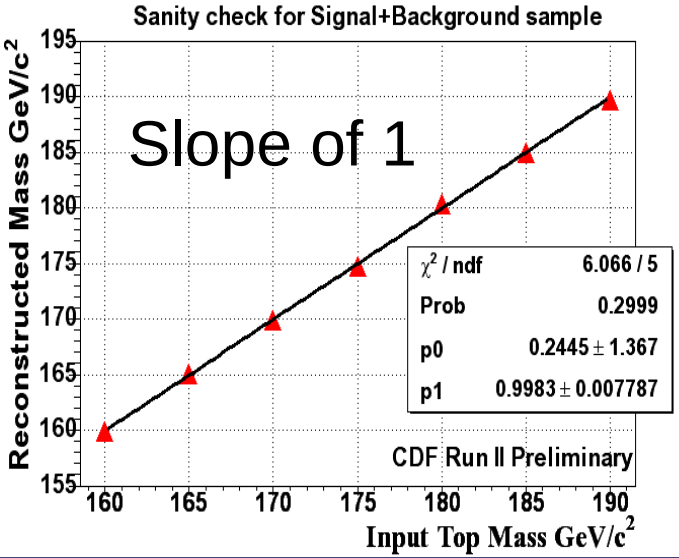
- The mapping function is obtained by 22 events PEs varying the background fraction with Poisson.
- Fit parameters are very stable.



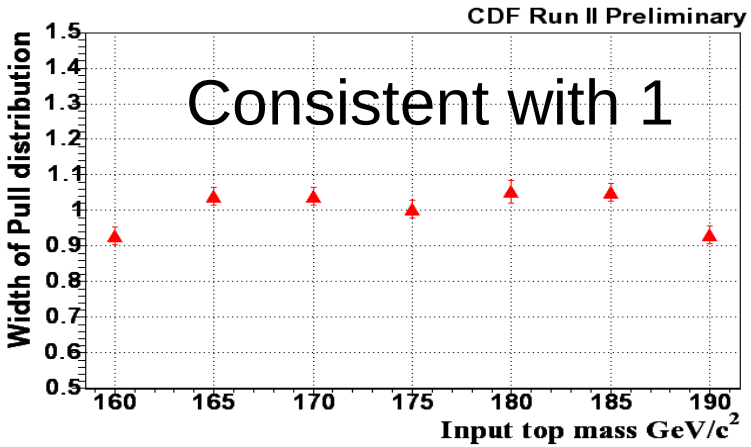
After applying mapping functions

(1) Sanity check (2) Width of Pull

(1)

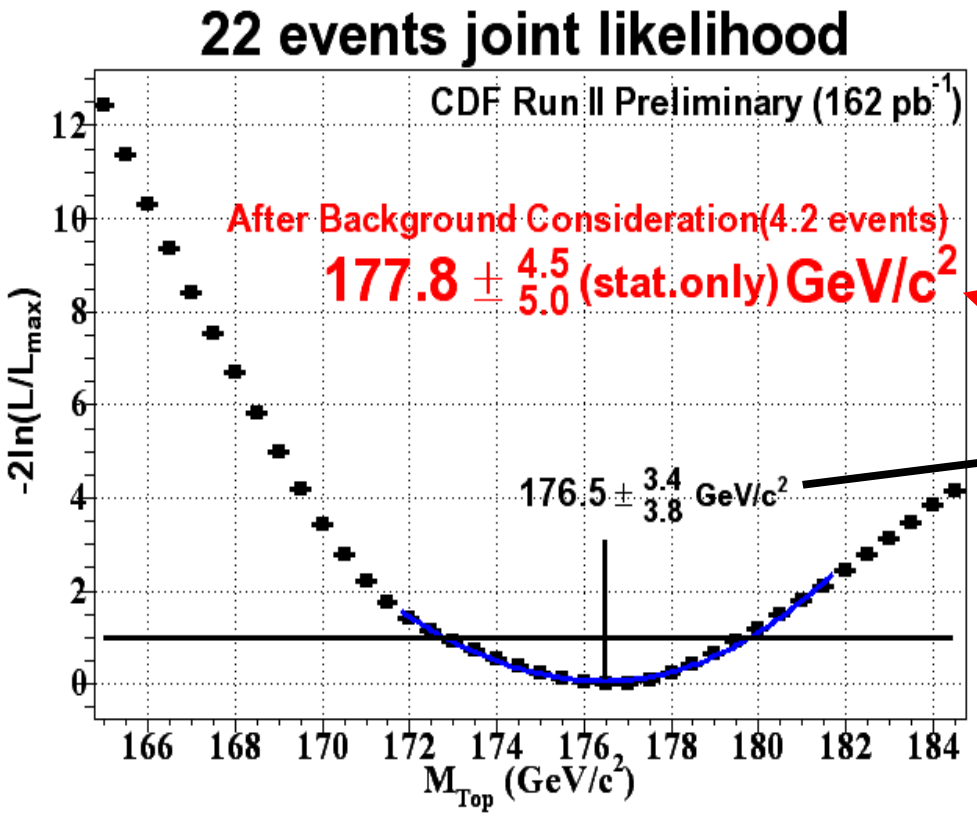


(2)

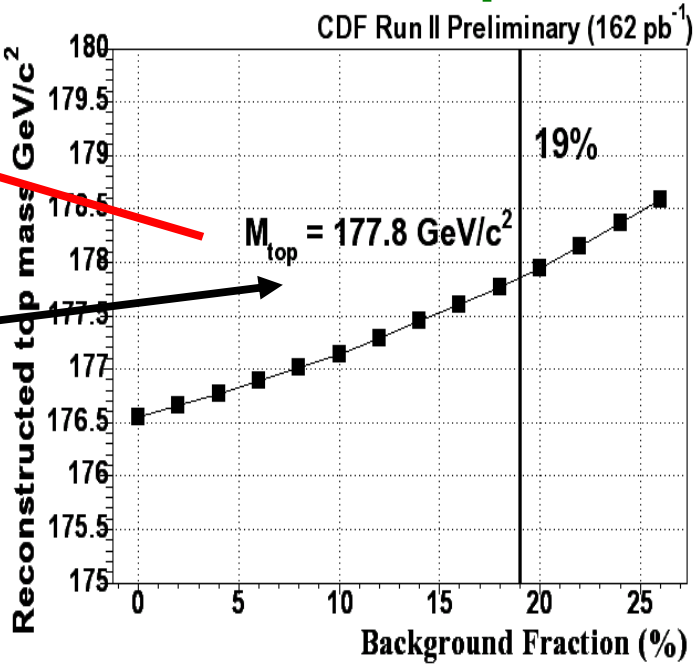


Extracted Top Quark Mass using L=162 pb^{-1} at CDF

- Observed events :Total 22(3) events; CEM 12(1), Muons 10(2)



Correct background-pulling
4.2 events expected.



Statistical Uncertainty

- **Expected statistical Error :**

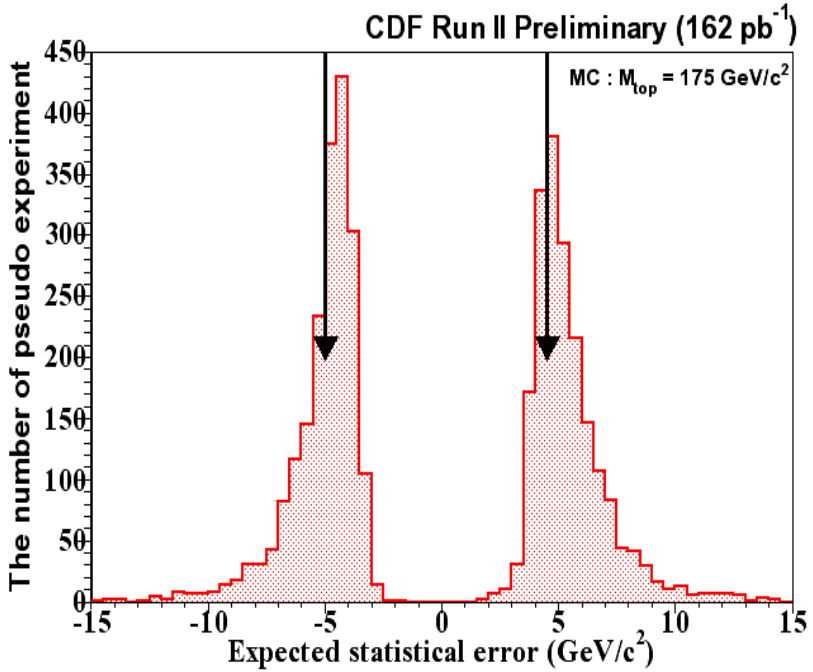
  Black arrows :

  Data : + 4.5, – 5.0 GeV

  Monte Carlo :

  Mean : + 5.4, – 5.0 GeV

  MPV : + 4.5, – 4.1 GeV



- **For the future -**

  Simple Prospect :

  - by Luminosity scaling

  Expect to be ~2 GeV(1fb^{-1}) by this single analysis. Improvement in progress!

Time (Expected)	Luminosity w/ silicon	Expected stat. Error
Summer 2004	~ 300 pb^{-1}	~ 3.7 GeV
Summer 2005	~ 600 pb^{-1}	~ 2.6 GeV
Summer 2006	~ 1 fb^{-1}	~ 2.0 GeV

Comparisons

- **Event-by-event Maximum Likelihood Mass with wide range of [125-225] GeV.**

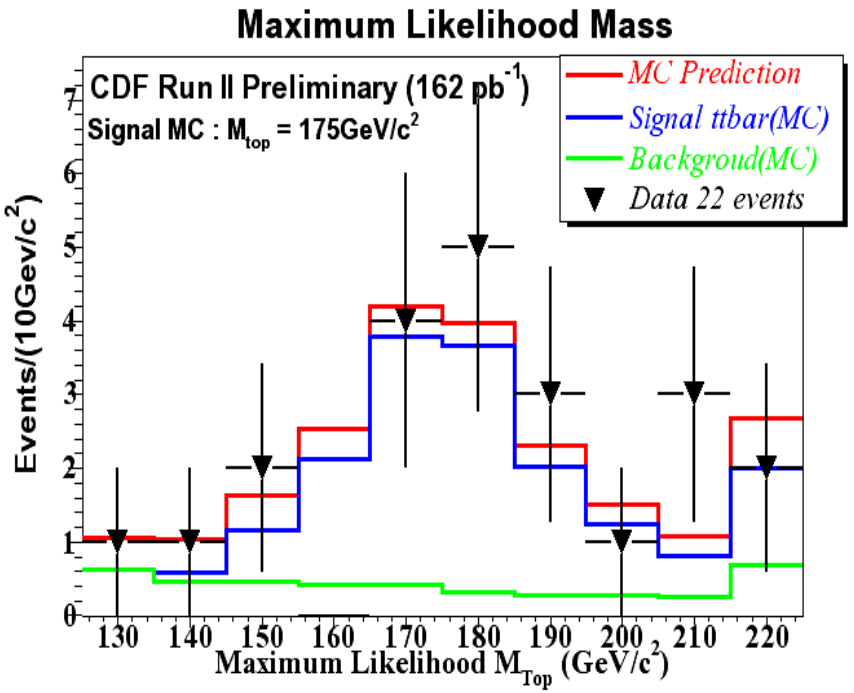
  Note : First(last) bin includes under(over) flow.

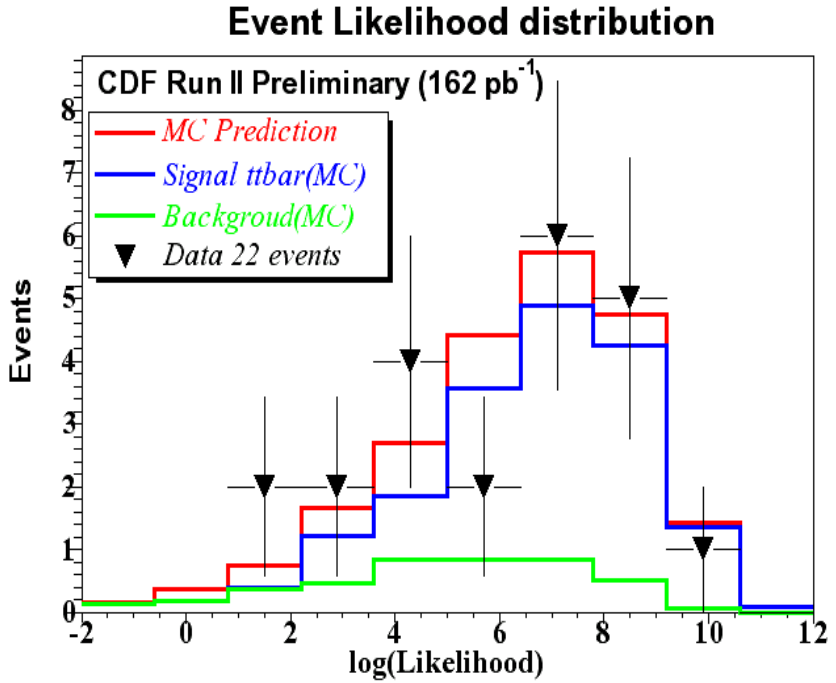
- **Event likelihood**

  For i-th event,

$$L^i_{ev} = \int L^i(M)\,dM$$

  A event has one likelihood value





Systematic Uncertainty

- All values are estimated by Pseudo experiments with background of 4.2 ev by MC
- Jet Energy is dominant
  ⟶ Improvements promised for summer, goes half?
- ISR/FSR : Not On/Off Monte Carlo with reasonable combination of Λ, Q^2
- PDF: different EigenVectors
- Fragmentation ambiguity is in transfer function error.

Sources	ΔM_{top}(GeV/c^2)
Jet Energy Scale	5.3
ISR	0.5
FSR	0.5
PDF	2.0
Generator	0.6
Spin correlation	0.4
NLO effect	0.4
Bkg fraction ($\pm$5%)	0.5
Bkg Modeling	0.5
MC Modeling	0.6
Transfer function	2.0
Total	6.2 GeV

Conclusions and Looking Ahead

- **We measured top mass to be,**

$$M_{top} = 177.8 \pm {}^{4.5}_{5.0}\ (stat.) \pm 6.2\ (syst.)\ GeV/c^2$$

using 22 exact-4-tight jets events (L=162 pb^{-1}).

- Systematic uncertainty is dominated by JES.
- Further sophistications of DLM : In progress(publication)
- Get more data, extend acceptance to measure top mass more precisely, goal is ~ ± 1 GeV in RunII.
- Hadronic W Mass Measurement.
- **The top mass can be used to determine top event kinematics by DLM. DLM is VERY powerful at the stage to look at beyond Standard Model!!!**